Broadband Primer

A Guide to High Speed Internet Technologies

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What is "Broadband?"

The term "broadband" generally refers to high-speed Internet connections transmitting data at speeds greater than 200 kilobytes per second (Kbps), compared to the 56 Kbps maximum speed offered by traditional dial-up connections. While traditional dial-up access (using normal voice telephone line technology) suffices for many consumers, some need or want the much faster connections that technological advances now allow.

This primer offers a brief description of each technology used to provide broadband services.

Topics covered include:

- Digital Subscriber Line (DSL)
- Coaxial Cable
- T-1 Lines
- Fiber-To-The-Home (FTTH)
- Wireless Fidelity (Wi-Fi)
- Satellite
- Broadband over Power Line (BPL)
- Broadband over Gas Line (BGL)

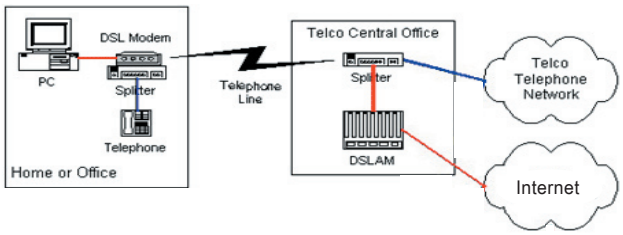
For a more basic overview of broadband services and options, please see the OUCC's "Broadband Internet Access: An Introduction" fact sheet.

Digital Subscriber Line (DSL)

Digital Subscriber Line (DSL) provides a dedicated digital circuit between a user's premises and the Internet through the telephone company's central office via ordinary copper telephone wires.

The two primary forms of DSL are Asymmetric Digital Subscriber Line (ADSL) and Symmetric Digital Subscriber Line (SDSL). ADSL has a higher download speed (1.544 to 6.1 Mbps downstream) and a lower upload speed (16 Kbps to 1.5 Mbps). SDSL's download and upload speeds (1.544 Mbps) are equal. SDSL does not provide voice capabilities. ADSL – which is more widely used and available – must be within 18,000 feet of the central office while SDSL users must be within 12,000 feet. Some companies, however, have begun to use new technologies such as fiber lines and/or repeaters to extend DSL capabilities up to 25,000 feet.

An ADSL modem has a "plain old telephone service" (POTS) splitter and a channel separator. The POTS splitter divides the phone line into two channels (voice and data) and the channel separator divides the data channel into two sections (downstream and upstream). Data are transported to another ADSL modem in the central office. This modem sends the voice calls to the public switched telephone network (PSTN) and sends the data to the digital subscriber line access multiplexer (DSLAM). The DSLAM connects many ADSL lines to a single asynchronus transfer mode (ATM) line or switch. This ATM line acts as both a traffic aggregator and as a multiservice switch that is capable of forwarding traffic in different ways, depending on needs. The ATM line then sends the data over the Internet.



Coaxial Cable

Cable television companies (Comcast, Insight, Brighthouse, Time Warner, etc.) are now competing with traditional telephone services by providing service over their own networks, usually Voice over Internet Protocol (VoIP). For more information on VoIP please refer to the OUCC's VoIP fact sheet.

If a consumer uses a cable service for broadband access, a cable modem connects the user's personal computer to a shared network, connecting the computer to the Internet via the cable company's main office (as shown below). Cable modems adhere to industry standards known as DOCSIS (Data Over Cable Service Interface Specification). These standards allow them to interact with other DOCSIS-certified equipment to ensure data privacy.

Cable companies can install new service to customers very quickly and easily if those customers are already using cable TV. In general, cable companies offer faster download and upload speed than traditional DSL if the network is not congested. Cable modems can accommodate data speeds up to 27 Mbps downstream and 10 Mbps upstream, but typical speeds generally average 1 to 3 Mbps.

Cable broadband speeds can be limited by congestion on the network, limiting providers' ability to guarantee broadband speeds. The cost of deploying cable can hinder providers' ability to extend service into low-density areas.

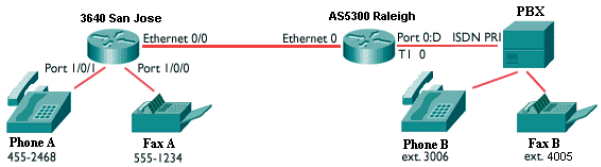
T-1 Lines

A T-1 line is a dedicated line supporting data rates up to 1.544 Mbps - using 24 individual channels with each supporting 64 Kbps. An individual channel can carry voice or data traffic, while a customer switching unit/ digital switching unit (CSU/DSU) is necessary to connect the channel to the four wires that carry the information. The CSU/DSU sends the data signal to the router which connects it to a server that may send it to the Internet via other servers.

Repeaters must be in place every 6,000 feet or less to help prevent data signal degeneration (as diagrammed below).

Telephone companies, in general, allow customers to buy individual channels in increments of 56 Kbps (8 Kbps per channel is used for data management). A full T-1 connection can theoretically accommodate 200+ users and other provider services.

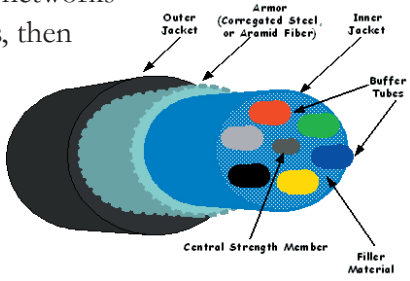
T-1 lines use copper wire and offer a popular option to businesses and smaller Internet service providers (ISPs) wanting to connect to the Internet and the Internet backbone (such as faster T-3 connections). Because of costs, T-1 service is generally not considered an effective method for reaching most rural areas or residential customers.



Fiber-To-The-Home (FTTH)

In an FTTH system, glass fiber cables go directly from the Internet backbone to the user's premises, using high-speed pulses of light to transport information. Fiber-optic cables have large bandwidth (speeds greater than 2.5 gigabits per second).

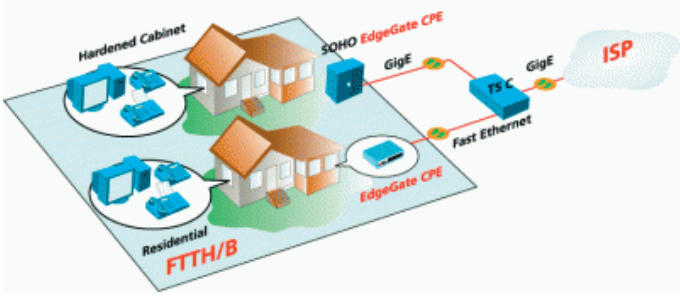
More and more, both traditional phone companies and start-up companies are installing FTTH to deliver broadband services, particularly in areas with new residential and commercial construction. Companies with older copper networks are, in some cases, overlaying copper-wired networks with new FTTH systems, then removing the old networks.



Two types of FTTH architectures are currently used: Point-to-point and passive optical network (PON).

Point-to-point providers install an optical transceiver in the provider's central office for each customer. Fiber-optic cable then connects the central office to the customer's premises, much like a telephone line.

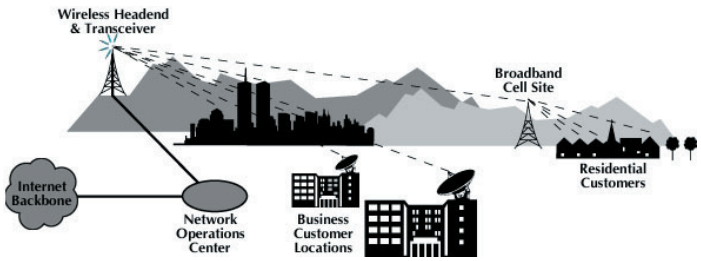
PON is a fiber optic network without active electronics, such as repeaters. A PON uses passive splitters to deliver signals to multiple terminal devices using a tree structure transmission network. PON systems use transceivers with splitters that may be located as far as 30,000 feet from the provider's central office. An optical electrical converter (OEC) installed on or near the customer's property converts the optical signal to an electrical signal, allowing it to connect to the end user.



Wireless Fidelity (Wi-Fi)

Wireless broadband systems use radio signals to send and receive data and voice at speeds ranging from 128 kbps to 1.5 Mbps. However, speeds are increasing every day and many Wi-Fi systems can transmit at speeds from 1-12 Mbps. In general, wireless providers offer Internet access via fixed wireless technology that relies on a stationary signal base. Wireless broadband services use the same radio frequency spectrum that supports pagers, cell phones, microwave signals and more.

With a fixed wireless system, the provider installs a small antenna (dish) at the user's premises which is wired to a modem on the user's computer. Radio waves sent from the user's antenna to the provider's antenna connect the computer to the Internet. For optimal usage, the user's antenna should have a clear line-of-sight to the wireless broadband provider's antenna. Bad weather, rugged topography and line-of-sight obstructions can impede service.



3G

Currently, third-generation mobile wireless services (3G) are coming onto the market that will allow users to access the Internet, transmit data and voice, and utilize various multimedia services at speeds of 2 mbps or higher.

3G technologies are turning telephones and other devices into multimedia players, making it possible to download music and video clips. The new service is called the freedom of mobile multimedia access (FOMA) and it uses wideband code division multiple access (W-CDMA) technology to transfer data over its networks. W-CDMA sends data in a digital format over a range of frequencies, which makes the data move faster (but also uses more bandwidth than digital voice services). W-CDMA is not the only 3G technology; competing technologies include CDMAOne, which differs technically but should provide similar services.

Wireless Fidelity

Wi-Fi networks are simply wireless networks that run under the 802.11b standard. 802.11b is a low power wireless system; the closer the user is to a transmitter, the faster the system will operate. The newest system, Wi-Fi 5, operates in the 5 MegaHertz (MHz) band and can offer speeds of up to 54 Mbps. One major advantage of Wi-Fi systems is a new architecture for wireless LANs combining Gigabit Ethernet switching, Wi-Fi technology, and new "smart" antennas. This new architecture allows Wi-Fi switches to send and receive multiple transmissions simultaneously, significantly extending the range of Wi-Fi systems.

Wi-Fi continues to see strong, rapid growth as many cities around the United States contract with providers to implement "Hot Spots" for wireless high-speed Internet service. A hotspot is defined as any location in which 802.11 (wireless) technology is available for consumer use (whether as a free or paid service).

Wi-Fi vs. Bluetooth

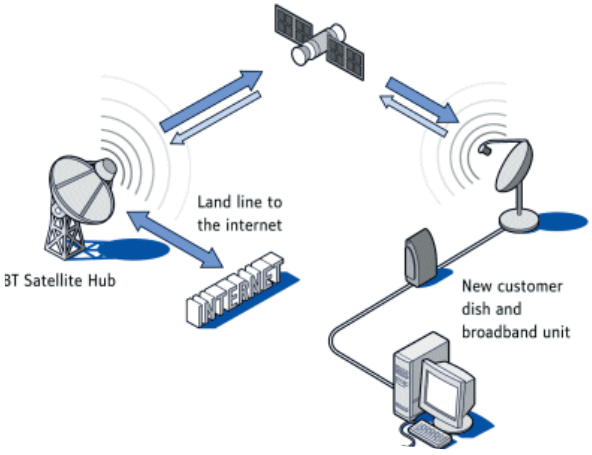
Because Wi-Fi and Bluetooth technologies work under different protocols, appliances using Wi-Fi and Blue-

tooth are not interoperable. Bluetooth is a computing and telecommunications industry specification that describes how mobile phones, computers and PDAs can easily interconnect with each other as well as telephones and computers using a wireless connection over very short distances. Bluetooth and Wi-Fi are different in a number of ways and should not be viewed as competitors. The biggest difference between the technologies is that Wi-Fi boasts faster data transfer speeds and range, making it a good replacement for Ethernet systems, while Bluetooth requires less power and is prominent in small systems such as personal digital assistants (PDAs).

Satellite

With some broadband systems, data signals travel from a computer to a satellite and are then beamed to the ISP where the request is processed.

The main advantage of satellite broadband is that it is available to nearly anyone who has an unobstructed view of the southern sky, since satellites orbit the Earth near the Equator. Rural customers who may not have access to other broadband technology can usually receive service via satellite.

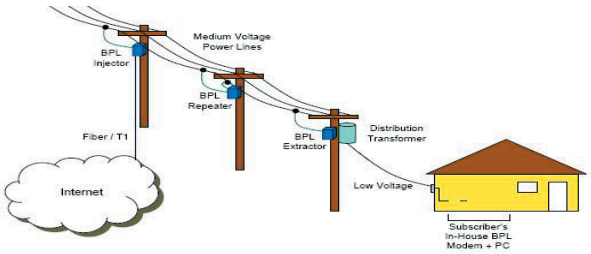


Satellite broadband has several limitations including upload and download delays, inclement weather disruptions, physical obstruction concerns, and costs to purchase, maintain and operate the necessary equipment. Due to the distance from the computer to the satellite, there is a delay of a half-second or more between information sent and data received. Inclement weather can increase the delay or disrupt satellite service altogether. Objects such as trees and buildings can severely restrict or prevent reception of satellite signals.

Satellite

Broadband Over Power Line (BPL)

As an emerging technology being deployed and tested, BPL penetration remains relatively low throughout the nation. BPL technology uses shortwave frequencies similar to those used by amateur radio operators, sending and receiving signals over the same wires that carry electricity.



The concept for the consumer is simple: Plug a computer into a special Internet modem the size of small books which, in turn, plugs into an electrical wall socket. Since high-speed data and voice signals cannot go through a transformer, BPL providers must install devices that combine the voice and data signals with the low-voltage supply current in local transformer stations. Regenerator units attached to the power line every half-mile filter out static and boost the signal. Most BPL systems operate at up to 500 Kbps – 10 to 20 times faster than dial-up and similar to DSL, but slower than cable. With current BPL technology, systems have the potential to come very close to cable speeds.

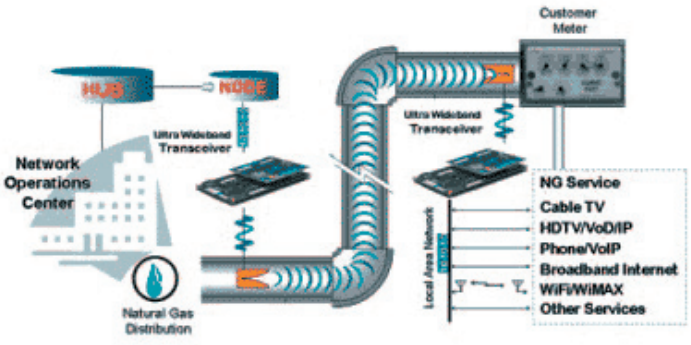
Growing numbers of electric utilities are considering joining long-distance telephone carriers and cable television companies in offering high-speed Internet service. However, BPL is still an experimental technology, with more than 40 field trials underway throughout the United States. BPL is currently being tested in at least two central Indiana markets.

Broadband Over Gas Line (BGL)

BGL is the latest emerging technology in the broadband arena. While not deployed commercially at this time, BGL holds potential promise for transmitting signals via natural gas pipelines and supply lines.

BGL

While this technology is in the early development stages and has yet to become a proven option, a California-based company - Nethercomm Corporation - expects to run its first pilot test for BGL in the summer of 2006, using technology as shown in the following diagram.



Comparing Your Options

Access speeds increase with new technology improvements. The following table gives an overview of the average time required to download specific activity examples using Internet access services (assuming optimal conditions) .

Internet Functions	Dialup (56K)	Satellite (512K)	DSL (1M)	Cable (1M)	Wireless (5M)
An e-mail	1 sec.	<1 sec.			
A basic Web page (25K)	10 sec.	<1 sec.			
One Five-Minute Song (5M)	15 min.	2 min.	1 min.		40 sec.
One Two-Hour Movie (500M)	20 hrs.	4 hrs.	2 hrs.		70 min.

Which Broadband is Best?

The right option for Internet access will depend on a consumer's needs and which services are available. The following table lists some of the advantages and disadvantages of current conventional broadband technology available to the average consumer.

Technology	Download Speed Typical (Mbps)	Uplink Speed Typical (Mbps)	Advantages	Disadvantages
Digital Subscriber Line (DSL)	.5-3	1.0	- Good upload rates - Uses existing telephone lines	-Speeds vary depending on distance from telephone company's central office -Slower downloads than less expensive alternatives
Cable	.5-4	.5-1	- Uses existing cable infrastructure - Low-cost equipment	-Shared connections can overload system, slowing upload times
T1/T3 Dedicated Line	1.5-3	1.5-3	-Uses existing phone wiring -Multiple ISP resellers	-Performance drops significantly with range -Susceptible to crosstalk
Fiber-to-the-Home (FTTH)	4.5	10.2	- Fast data speeds -Infrastructure has long life expectancy -Low maintenance -Low power costs	-Not widely available at this time -Significant deployment cost (for company)
Fixed Wireless	.5-12	.5	-Typically inexpensive to install, no underground digging	-Weather, topography, buildings, and electronics can cause interference
Satellite	.5-2	.05	- Nearly universal coverage available in otherwise inaccessible areas	-Expensive service/equipment -Upload/download delays
Broadband Over Power Line (BPL)	.5-4	.5-4	-Uses a building's existing electrical wiring	- New technology being introduced Currently not widely available
Broadband Over Gas Line (BGL)	40.9 (potential)	40.9 (potential)	-Has the potential to be much faster than other options	- New technology being developed Still in experimental stages

SOURCES:

DSL diagram: http://support.easystreet.com/easydsl/general-info/dsl-basics.htm

Cable diagram: http://www.homenethelp.com/web/diagram/share-router-hub.asp

T-1 Lines diagram: http://www.cisco.com/en/US/tech/tk652/tk653/technologies_configuration_example09186a00800fa11a.shtml#diag

FTTH diagrams:
(cable): http://ops.fhwa.dot.gov/publications/telecomm_handbook/chapter2_01.htm
(network): http://www.telco.com/solutions/ftth/neighborhood.stm

Wi-FI diagram: http://www.cabledatacomnews.com/wireless/diagram01.html

Satellite diagram: http://www.hie.co.uk/aie/bbsat.html

BPL diagram: http://www.puc.state.tx.us/about/commissioners/parsley/present/epp/ri_broadband051204.pdf

BGL diagram: www.gizmag.com/watermark.php?p=4039_15050585222

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6/06